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## Factors Influencing the Development of the Czech Crown

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### Abstract

Lots of possible explanations of the development of the exchange rate can be found in the available literature. The aim of this paper is to find which factors influence the development of the Czech currency (measured as real bilateral exchange rate compared to euro area – CZK/EUR expressed in real terms) and to assess periods with overvalued and undervalued exchange rate. A long run relationship among exchange rate, approximation of Balassa-Samuelson effect, short run interest rate differential, government debt differential, terms of trade, government expenditures and domestic and foreign investments has been found using quarterly data for 2000Q1–2015Q3 periods.

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**Keywords:** Equilibrium Exchange Rate; the Czech Republic; Cointegration; Balassa-Samuelson effect; Productivity

### 1. Introduction

The knowledge of Equilibrium Exchange Rate (EER) is important for both policy makers and market participants. Komárek and Motl (2012) declare four reasons why central bank should monitor estimates of equilibrium exchange rate. The first one is to gather knowledge for monetary policy implementation. The second motive is that knowledge of EER level helps central banks to set policy instruments. The third reason is that exchange rate is a key factor for evaluation the competitiveness of whole economy. The last reason, which is very important especially in the case of the Czech Republic, is that information about EER is a crucial factor when setting central parity or conversion ratio before joining a common monetary union. Market participants, for example, can utilize the knowledge of EER to identify an investment opportunity.

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Moreover, the real exchange rate misalignments have their negative impacts. Frait et al. (2006) claim that the risks implied by the overvaluation of currency are more important for policy makers, than those implied by the undervaluation of currency. Overvalued currency leads to lower economic growth (via the impact on manufacturing); unsustainable current account deficits; and increasing external debt and risk of speculative attacks.

The aim of this paper is to find which factors influence the development of the Czech currency (measured as real bilateral exchange rate compared to euro area – CZK/EUR expressed in real terms) and to assess periods with overvalued and undervalued exchange rate.

Firstly, there are mentioned theoretical and empirical backgrounds of EER. Then, there are described used methods and data. In the next part, the results are presented. Conclusions and discussion remain the last part of this paper.

## 2. Theoretical and empirical backgrounds

### 2.1. Determination of exchange rate and concepts of equilibrium exchange rate

One of the oldest theories, explaining the development of exchange rate, is the Purchasing Power Parity Theory (PPP). PPP proposes that the only determinant of exchange rate development is price level (in the case of absolute version of PPP), respectively inflation rate (in the case of relative one). Nevertheless, there exist some reasons (such as the Ballasa-Samuelson (BS) effect) why this theory does not provide good explanation of exchange rate development especially in the case of transitive economies. Another traditional theory is the Uncovered Interest Parity Theory (UIP). Since PPP deals with international movement of goods and services, UIP deals with international movement of capital flows. UIP declares that expected change in the nominal exchange rate is determined by the interest rate differential. Nevertheless even UIP does not provide good empirical results. That is why EER concepts have become popular. The first one is called Capital Enhanced Equilibrium Exchange Rate (CHEER, developed by Johansen and Juselius (1992)) and it is actually combination of PPP and UIP. It claims that PPP holds in the long-run, and that the difference in domestic and foreign interest rates can cause short-run misalignment between spot exchange rate and exchange rate defined by PPP. Behavior Equilibrium Exchange Rate (BEER), created by MacDonald (1997), is based on above mentioned approaches but it also tries to find other determinants of exchange rate development. Škop and Vejrnělek (2009) call it a statistical approach because it uses statistical methods to find determinants of exchange rate development (so called data mining). BEER approach is the most similar approach to this paper. For other approaches to EER such as Fundamental Equilibrium Exchange Rate (FEER), Desired Equilibrium Exchange Rate (DEER), Atheoretical Permanent Equilibrium Exchange Rate (APEER), Permanent Equilibrium Exchange Rate (PEER) or Natural Real Exchange Rate (NATREX), see e.g. Driver and Westaway (2003), MacDonald (2000) or Ěgert et al. (2006).

### 2.2. Review of empirical literature

Komárek and Motl (2012) compute BEER and FEER for Czech Republic using quarterly data (from 1996:Q1 to 2011:Q4). They estimate real (bilateral) exchange rate (CZK/EUR). As concerns BEER, the cointegration analyses are used. Depending variables are productivity difference, net foreign assets and ratio of real investments and export on GDP. The results confirm the estimates of exchange rate overvaluation by mid-1997 and in 1998, 2002 and 2008. Since 2009, the model suggests a significant slowdown in the appreciation of the equilibrium. Škop and Vejrnělek (2009) estimate NATREX. Quarterly data covered 1995:Q1–2007:Q4 period. They construct VECM while depending variables are output gap, time preference gap and terms of trade gap. They find that exchange rate is overvalued in 1995–1998 periods and that NATREX appreciated in long run. Babetskii and Ěgert (2005) estimate BEER for Czech Republic. They use monthly data from 1993:M1 to 2004:M9. They apply several alternative cointegration techniques and identify a period of an overvaluation in 1997 and in 1999, an increasing overvaluation until 2002, an undervaluation in 2003 and a correction towards equilibrium in the second half of 2004. Komárek and Melecký (2005) estimate BEER in 1994:Q1–2004:Q1. As determinants of the real equilibrium exchange rate they consider the productivity differential, the interest rate differential, the terms of trade, net foreign direct investment, net foreign assets, government consumption and the degree of openness. They find that the exchange rate is on average undervalued over the period 1994 to 2004 by about 7 percent with respect to the estimated BEER.

### 2.3. Determinants of exchange rate

This assumption to EER is based on UIP adjusted for risk premium:

$$EER = f(r_{dif}; \sigma), \quad (1)$$

where EER stands for equilibrium exchange rate,  $r_{dif}$  is real interest rate differential and  $\sigma$  represents risk premium, as Driver and Westaway (2003) claim. Nevertheless, authors dealing with BEER approach include a lot of various determinants, which often have an ambiguous effect on EER. In this paper, variables are divided into groups depending on their theoretical effects on development of exchange rate. The equation of EER therefore can be written as:

$$EER = f(r_{dif}; \sigma; PROD; TRADE; OTHER), \quad (2)$$

where *PROD* is a group of variables approximating productivity or BS effect, *TRADE* represents group of variables dealing with international trade and *OTHER* includes other variables influencing EER such as government spending or investments.

#### Interest rates (+/-)<sup>†</sup>

Since this assumption is based on UIP, another important variable is real interest rate differential. This variable is considered as an indicator of attractiveness of domestic currency, hence faster growth of domestic interest rate should lead to appreciation of domestic currency. On the other hand, the growth of domestic interest rate may (i) lead to higher inflation expectations, growth of demand for foreign currency (instead of domestic one) and depreciation of domestic currency; (ii) indicate that central bank makes an effort to increase an income of foreign investments to improve deficit of current account, which can work in short run only, and in the long run, depreciation of domestic currency is inevitable; (iii) indicate growth of government debt (higher government debt leads to higher interest rates via growth of demand of money), which can lead to distrust of creditors to domestic currency and to its depreciation. From these reasons the effect of difference in domestic and foreign real interest rate is considered as ambiguous. The short run (money market) real interest rate differential is used in this paper and the variable is labeled as *sir*.

#### Risk premium (+, +-)

As MacDonald (2000) claim the UIP condition should be adjusted for risk premium. A higher risk premium usually leads to depreciation of domestic currency. The question here is how to measure the risk premium. There are several possibilities. The first option, suggested by MacDonald (2000), is to proxy it using the ratio of domestic government debt to foreign government debt both as percentage of GDP (*debt*). Next possibility, used by Frait et al. (2006) for example, is to use net foreign assets (*nfa*). Deficit of current account leads to increase of foreign debt, which is financed by foreign investors, who demand (to adjust their portfolios) a higher yield. At given interest rates, this can only be accomplished through a depreciation of the currency of the debtor country. Nevertheless, changes of NFA in reaction to exogenous shocks could be offset by adjustments in the capital stock. Since changes in the net foreign asset position and changes in the capital stock have countervailing effects, the impact on the EER may be ambiguous as Maeso-Fernandes et al. (2001) claim. The last option is to use long term real interest rate (*lir*) of government bonds. Since time horizon for both domestic and foreign interest rate is the same, the difference in the real interest rate can be considered as a risk premium. The advantage of this assumption is that it takes into account real market situation, whereas the other options seem to be an implicit approximation.

#### Productivity and BS effect (-)

Most empirical papers, such as Frait et al. (2006) or Bitans (2002), unambiguously consider faster growth of productivity in domestic country than in foreign one as a crucial factor of real appreciation of domestic currency. Productivity is usually measured as a ratio of domestic real GDP per capita to foreign one. This assumption is represented by variable *dprod*. On the contrary, MacDonald (2000) suggests measuring the productivity as a ratio of tradable to non-tradable goods (proxied as ratio of CPI to PPI). Nevertheless, there are some problems with this

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<sup>†</sup> (+) and (-) represent expected sign of variables, where (-) stands for appreciation, whereas (+) means depreciation of domestic currency. (+/-) is used for those variables which impact is ambiguous.

assumption. Firstly, price indices seem to be a rough estimate of tradable and non-tradable goods. Moreover there can be a problem of multicollinearity of variables in particular case of this paper. That is why another variable is used for measured productivity growth of tradable sector in this paper. Variable *dprodt* measures productivity differential as a value added only in manufacturing. The last proxy of productivity measures BS effect. In this case manufacturing is consider as tradable sector and the rest of economic activities is consider as non-tradable. Variable related to BS effect is labeled as *bs*.

#### International trade (+–)

Variables linked to international trade are another important determinants of development of EER. MacDonald (2000) uses terms of trade (*tot*, the ratio of export prices to import prices) and claims that improvement in terms of trade leads to appreciation of domestic currency (–). Since Czech economy is considered as a small and open economy, another important variable is the openness of economy (*open*). Some authors, such as Égert and Lommatzsch (2004) or Kim and Korhonen (2005) claim, that the more economy is open the weaker exchange rate will be (+). On the other hand, some studies, such as IMF (1998) or Maurin (2001), state that growth of openness of economy leads to appreciation of domestic currency (–). As Komárek and Motl (2012) claim, next determinant of development of EER is ratio of net export (*nx*) to GDP. The more domestic export is higher than domestic import, the stronger domestic currency will be (–).

#### Other determinants (+–)

Another often used variable is government spending (*gov*), usually expressed as the ratio to GDP. Most authors, such as Fischer (2002), Halpern and Wyplosz (1997) or Kim and Korhonen (2005), say that higher government spending leads to appreciation of domestic currency (–). On the other side, there are authors, such as Bitans (2002) or IMF (1998), who state that higher government spending leads to depreciation of domestic currency (+). The last two variables deal with investment. The volume of domestic investment (*inv*) is measured as ratio of investment to GDP. Kim and Korhonen (2005) claim that growth of this variable should cause appreciation of domestic currency (–), whereas IMF (1998) says that it is contrariwise (+). Foreign investments are measured as foreign direct investment (*fdi*) and it is expected that their growth lead to appreciation of domestic currency (–) as Frait and Komárek (1999) claim.

### 3. Research methods and data

#### 3.1. Methods

Since the goal of EER approach is to find long run relationship between variables influencing development of exchange rate, the cointegration analysis is used in this paper. Johansen cointegration tests (Johansen (1991)) are the most common tests of cointegration as Cipra (2013) claims. The advantage of these tests is that they permit more than one cointegration relationship. There exist two types of Johansen cointegration tests:

- $\lambda_{\text{trace}}$  statistic

$$\lambda_{\text{trace}}(r) = -n \sum_{i=r+1}^m \ln(1 - \hat{\lambda}_i), \quad (3)$$

with hypothesis H0: number of cointegration relationships  $\leq r$  and H1: number of cointegration relationships  $> r$ . And

- $\lambda_{\text{max}}$  statistic

$$\lambda_{\text{max}}(r) = -n \cdot \ln(1 - \hat{\lambda}_{r+1}), \quad (4)$$

with hypothesis H0: number of cointegration relationships =  $r$  and H1: number of cointegration relationships =  $r + 1$ .

Once Johansen tests indicate cointegration between variables, Vector Error Correction Model (VECM) is estimated. When Error Correction Term (ECT) is negative and significant, there is a long run relationship between variables. The length of lag for each model is based on Sequential modified LR test statistic (each test at 5% level),

Final prediction error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SC) and Hannan-Quinn information criterion (HQ). EViews 7 software is used.

### 3.2. Data

At first, it is important to define exchange rate measure. Since the euro area is the most important trade partner of the Czech Republic, the bilateral exchange rate (CZK/EUR) is used in this paper. Nominal exchange rate is deflated using PPI, because it seems to be better approximation of prices of tradable goods than CPI. For detailed discussion about how exchange rate should be defined and which price index should be used, see Driver and Westaway (2004). Variable approximating exchange rate is labelled as *rer*. Data for nominal exchange rate (quarterly averages) were obtained from ARAD – Time Series System (ČNB, 2015). Price index (PPI) data were gathered from Eurostat Database (Eurostat, 2015).

3 month (money market) interest rates are used for variable *sir*. Nominal data are deflated using CPI inflation rate (quarterly data were computed as non-weighted average from monthly data). Data for both nominal interest rates and inflation rate were gathered from Eurostat Database (Eurostat, 2015).

Variable *debt* was computed as the ratio of government debt per GDP of the Czech Republic to government debt per GDP of euro area. Data for both quarterly nominal government debt and quarterly nominal GDP were gathered from Eurostat Database (Eurostat, 2015). Variable *nfa* is defined as a net investment position of the Czech Republic. Since all values were negative, absolute values are used. Growth of this variable therefore means growth of foreign debt. Data were obtained from ARAD – Time Series System (ČNB, 2015). Long term government bond (Maastricht criterion) is used for variable *lir*. Data were gathered from Eurostat Database (Eurostat, 2015).

Variable *dprod* is computed as a ratio of real GDP per employee of Czech economy to euro area. Variable *dprod<sub>t</sub>*, representing tradable sector only, is computed as ratio of value added per employee in relevant sector (manufacturing) of Czech economy to euro area. Approximation of BS effect – variable *bs* – was computed as a difference between growth of value added in tradable sector (manufacturing) compared to not tradable sector (all other activities) in Czech economy relatively to euro area. Data for GDP, value added and employment were obtained from Eurostat Database (Eurostat, 2015). Data were seasonally adjusted by author (using Census X12 method). Nominal data were deflated using GDP deflator.

Variable *tot* is defined as ratio of export to import prices of Czech economy. Data were gathered from ČSÚ database (CZSO, 2015). The openness of Czech economy (*open*) is computed as sum of nominal export and import divided by nominal GDP. The net export (*nx*) is net export (export – import) per nominal GDP. Export and import data were obtained from ČSÚ database (CZSO, 2015).

Variables *gov* and *inv* are computed as ratio of government consumption (domestic investment respectively) per nominal GDP. Seasonally adjusted data were obtained from ČSÚ database (CZSO, 2015). Variable *fdi* is defined as foreign direct investment from foreign to the Czech Republic. Data were obtained from ARAD – Time Series System (ČNB, 2015).

Missing values are computed using EViews 7 software, logarithm transformation is used where it is possible and 2000Q1 = 1. Quarterly data cover 2000Q1–2015Q3 periods.

## 4. Results

In the case of cointegration analysis, it is needed that all (or at least some of them as Clark and MacDonald (1998) show) variables are integrated on the same level (usually I(1)). That is why tests for stationarity are run.

Table 1. Results of ADF test

Variable	ADF – p value	
	level	1 <sup>st</sup> difference
<i>prumP</i>	0.3354	0
<i>dprod</i>	0.054	0
<i>dprodt</i>	0.1206	0
<i>BS</i>	0.0086	0
<i>sir</i>	0.1164	0.0004
<i>debt</i>	0	0
<i>nfa</i>	0.1556	0
<i>lir</i>	0.2919	0.0005
<i>tot</i>	0.0619	0
<i>open</i>	0.8127	0
<i>nx</i>	0.6702	0
<i>gov</i>	0.0373	0.0024
<i>inv</i>	0.6944	0
<i>fdi</i>	0.4181	0.0369

Results of Augmented Dickey-Fuller tests are depicted in the Tab. 1. From the list of variables, several models are estimated using VECM. All models are tested using Johansen cointegration test.

The primary model is estimated according to MacDonald (2000). Model includes variables *dprod*, *sir*, *debt*, *nfa* and *tnt*. Nevertheless, except for variable *debt*, all variables turn out to be insignificant in the case of the Czech Republic. Next models are constructed according to following rules:

- only one variable for productivity is used,
- at least 4 variables are used,
- at most 8 variables are used,
- variables which are insignificant in most models are no longer used,
- variables which are significant and has a right sign in most models are used more often than the others,
- at least one variable from each group (except for group *OTHER*) is used,
- only models, where Johansen cointegration tests indicate cointegration, are considered.

Only five models, which provide the best results (based on sign and significance of error correction term and variables; R-squared statistic; Log likelihood, Akaike information criterion and Schwarz criterion) are presented in the Tab 2.

Table 2. Results of VECM

Variable	Expected sign	Model				
		A	B	C	D	E
<i>Dprod</i>	–			0.0628***		
<i>Dprodt</i>	–					
<i>BS</i>	–	–0.1170***	–0.1417***		–0.1299***	–0.1569***
<i>sir</i>	+–	–0.0010***	–0.0007	0.0328***	0.0231***	0.0255*
<i>debt</i>	+	–0.0687***	–0.2471***	0.3468***		0.0621
<i>nfa</i>	+–			–0.001		
<i>Lir</i>	+		0.0078***	–0.0303***	0.0089**	
<i>tot</i>	–	0.0292***	0.0348***	–0.0220***		
<i>open</i>	+–			0.0178***	–0.0582***	–0.0426***
<i>nx</i>	–			–0.1875***	0.5164***	0.3242***
<i>gov</i>	+–	–0.5020***	–0.1509***			
<i>inv</i>	+–	–0.2953***	–0.5368***		–1.2056***	–1.4269***
<i>fdi</i>	–	–0.0066**	–0.0121***			
Error corection term		–0.5277***	–0.3887*	–0.2665	0.0534	0.0807
R-squared		0.7997	0.8098	0.7391	0.7401	0.6869
Adjusted R-squared		0.5244	0.4579	0.2565	0.2747	0.3625
Log likelihood		1081.154	279.3288	270.1709	265.2997	264.8736
Akaike information criterion		–27.626	–8.3217	–8.0059	–8.0105	–8.0991
Schwarz criterion		–17.679	–6.9717	–6.6559	–6.6843	–7.0333
Lags		4	4	4	5	4

Note: – stands for appreciation; values of coefficients are depicted for each variable; each model includes intercept; \*, \*\*, \*\*\* denote 10%, 5% and 1% level of probability respectively.

Based on mentioned criteria, Model A seems to be the best model describing development of the Czech exchange rate. There exists a long run relationship between variables as ECT indicates. All variables except for *debt* and *tot* have a right sign. Nevertheless, time horizon is important for these variables, as Frait et al. (2006) claim, and its effect can be ambiguous too. Growth of terms of trade leads to depreciation in model estimated by Fischer (2002) for example. Estimated values are filtered using Hodrick-Prescott (HP) filter to eliminate short run biases. Development of both real bilateral exchange rate and EER are depicted in Fig. 1. Higher values of CZK/EUR (in real terms) than values of EER indicate periods of undervalued currency and *vice versa*. Real exchange rate seems to be overvalued in 2001–2002, 2004, 2007–2008, 2010–2011 and 2015 periods.

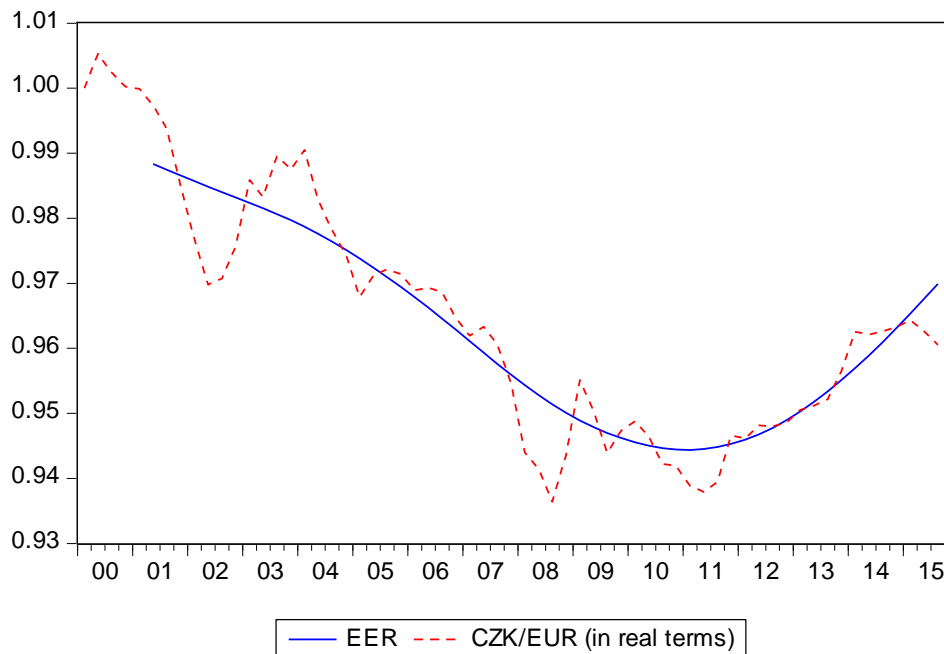


Fig. 1. Development of CZK/EUR (in real terms) and EER in the Czech Republic

Note: Time on the horizontal and exchange rate (2000Q1 = 1) on the vertical axis; lower values indicates appreciation of domestic (Czech) currency.

## 5. Conclusions

The aim of the paper was to find which factors influence the development of the Czech currency (measured as real bilateral exchange rate compared to euro area – CZK/EUR expressed in real terms) and to identify periods with overvalued and undervalued exchange rate. Several empirical models were estimated and tested. The best results provided Model A. A long run relationship among exchange rate, approximation of Balassa-Samuelson effect, short run interest rate differential, government debt differential, terms of trade, government expenditures and domestic and foreign investments was found. It is interesting that traditional measurements of productivity (differential between growth of real GDP per employee or growth of GDP for tradable goods per employee) seem to be insignificant, or furthermore have opposite effect in the case of the Czech Republic. On the other hand, approximation of BS effect was significant in most models specification. Short run interest rates, as well as government spending and domestic and foreign investments, influenced development of Czech currency as it was expected. On the other hand, growth of government debt relatively to foreign led to appreciation of Czech crown. Also development of terms of trade had opposite effect, than it was expected. In the case of these variables, time horizon played a role. Based on Model A, the development of EER was estimated for the Czech Republic. Real exchange rate seemed to be overvalued in 2001–2002, 2004, 2007–2008, 2010–2011 and 2015 periods.

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